

# Informational Leaflet 78

## FRAZER LAKE SOCKEYE SMOLT INVESTIGATION 1965

By:

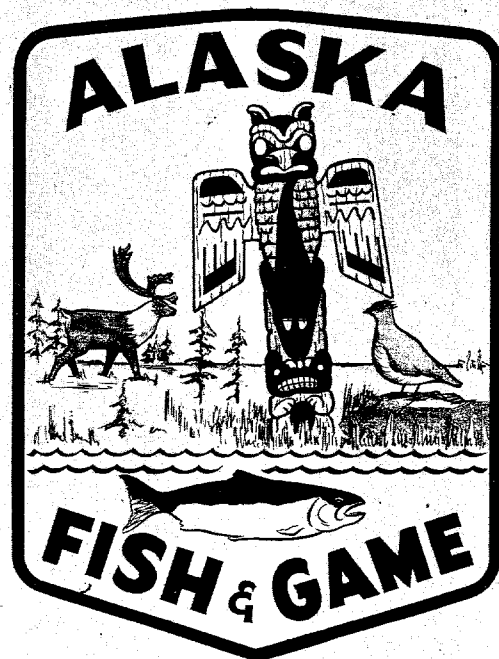
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FRAZER LAKE SOCKEYE SMOLT INVESTIGATION, 1965

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## TABLE OF CONTENTS

	Page
Introduction	1
Purpose	4
Construction of Smolt Weir	4
Sampling Procedure	5
Timing of Smolt Migration	7
Length-frequency Distribution of Smolts	9
Age Class Distribution of Smolts and Timing by Age	9
Condition Factor	15
Predation on Smolts	17
Summary	19
References	20

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## INTRODUCTION

Frazer Lake is located on Kodiak Island at latitude 57° 15' north and longitude 154° 10' west and is approximately eight miles long and one mile wide (Figure 1). The outlet stream, called Dog Salmon Creek, empties into Olga Bay approximately seven miles south of the lake and has a maximum depth of 10 feet and a maximum width of 150 feet. A falls approximately 1/2 mile below the lake blocked all adult fish passage until a fish pass was constructed in 1962 (Figure 2).

In 1951 work was begun to establish a sockeye salmon (Oncorhynchus nerka) run in Frazer Lake. Various methods were utilized: (1) egg planting, (2) fry planting, and (3) adult transplanting. The first progeny of these plants returned to the falls below the lake as spawning adults in 1956. Since the first return of six adults, the run has increased to approximately 5,000 adults per year and seems to be increasing. Counts of returning adults have been made since 1956, but downstream migrant counts were not made until 1965.

In the 14 years since the first eggs were planted, smolt sampling has been attempted several times, but with little success. The methods used for sampling included the use of fyke and gill nets. The fyke nets were placed above and below Dog Salmon Falls, but due to weather and timing the nets were used unsuccessfully and smolt capture was inadequate. Gill nets were used in the lake (Field notes of Dale Lockard, Fish and Game Aide, 1956), but only

Figure 1. Map of Kodiak Island showing the location of Frazer Lake in relation to Karluk Lake, Olga Bay, and the City of Kodiak.

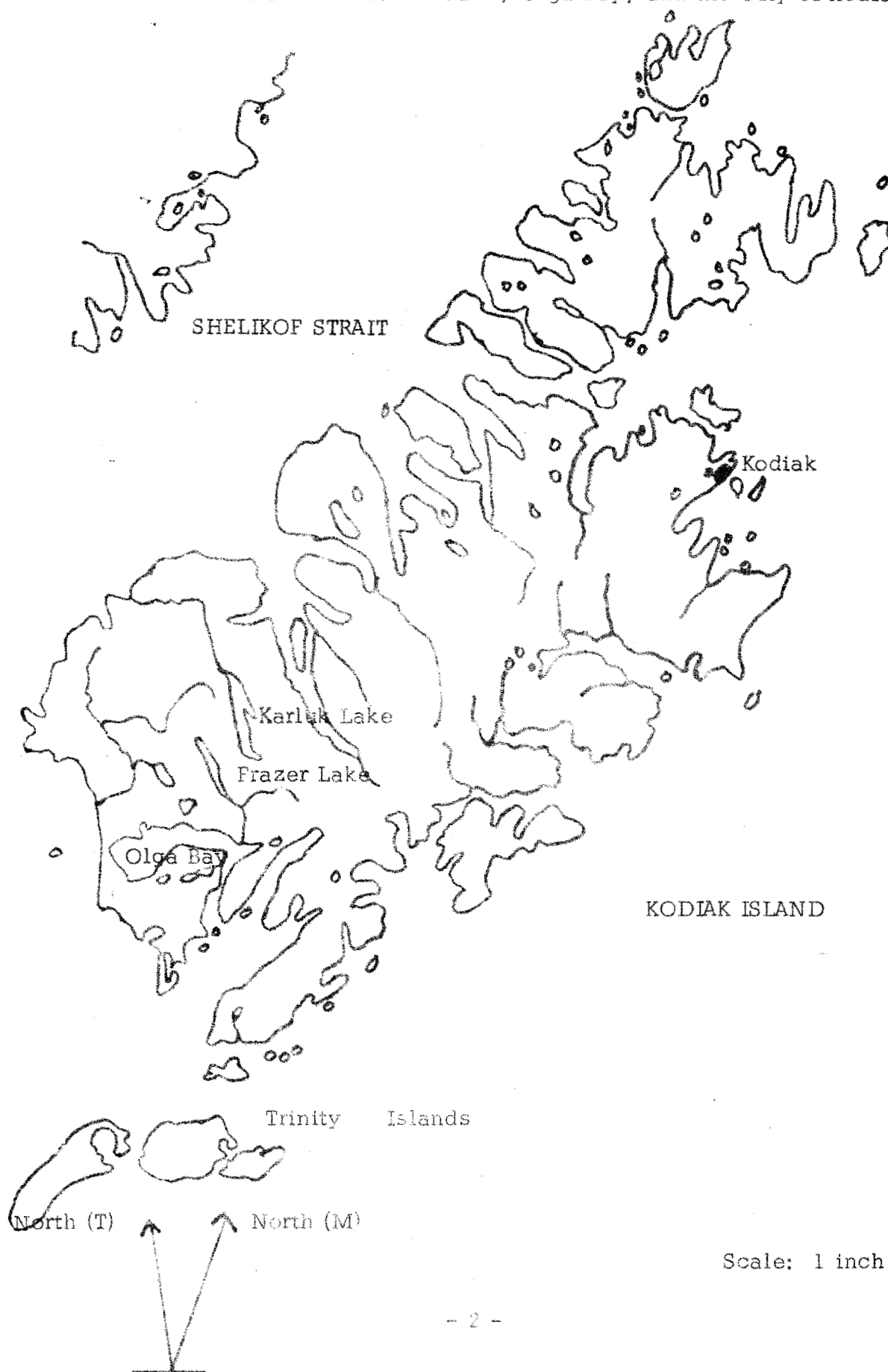
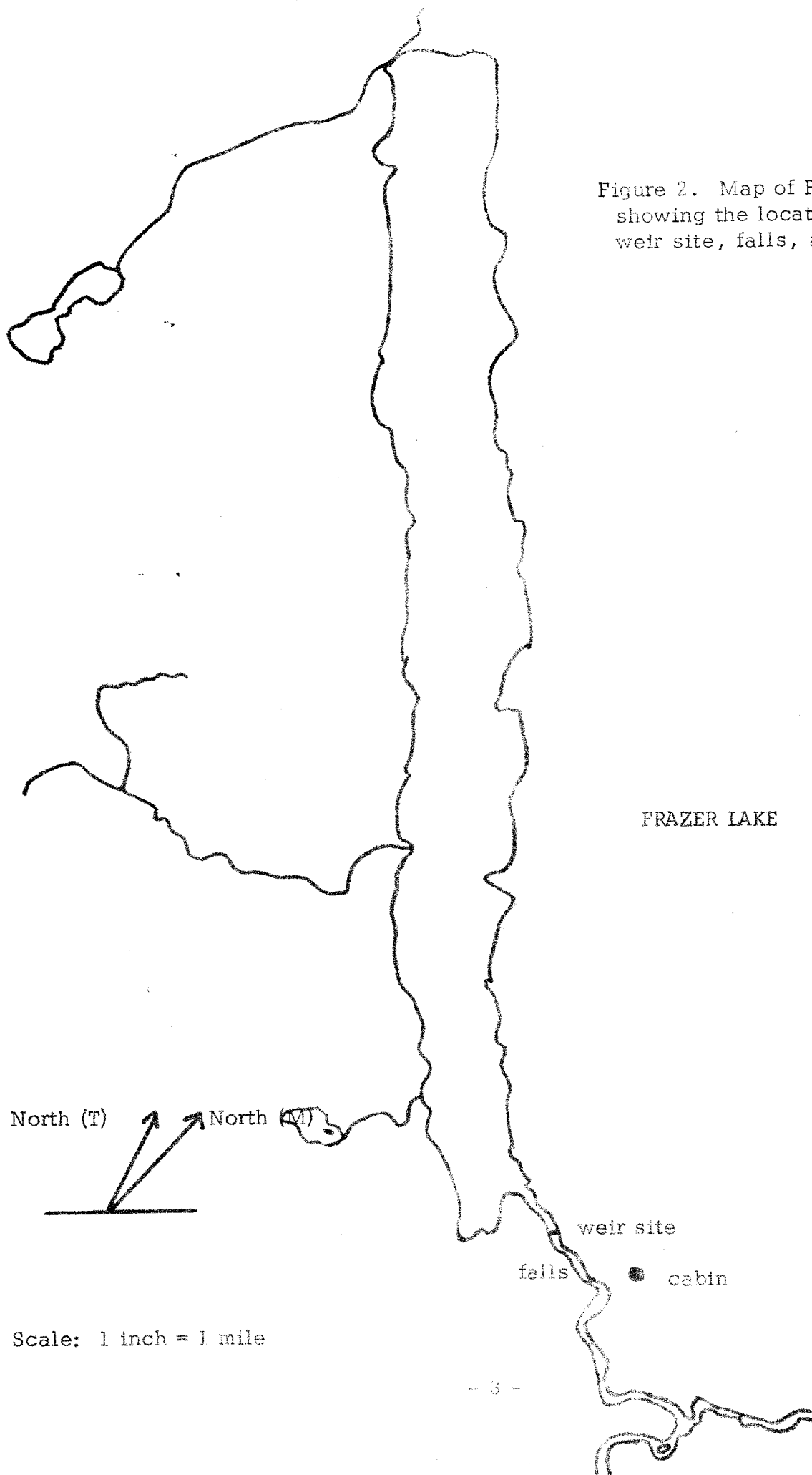


Figure 2. Map of Frazer Lake showing the location of the weir site, falls, and cabin.



Dolly Varden char (Salvelinus malma) were captured.

In July of 1956 a weir was constructed below the falls, primarily to capture returning adults which were then released in the stream above the falls and secondarily to sample downstream migrants. From June 12 through July 21, the smolt trap caught a few coho salmon smolts (O. kisutch) and Dolly Varden char, but no sockeye smolts. The inefficiency of the trap was due to the large meshed chicken wire screen used for the weir facing which permitted the smolts to elude the smolt trap. The main reason that previous smolt work was ineffective was probably because of the inadequate effort in this type of sampling. Although the fyke and gill net techniques were limited in scope, the weir technique was good, but faultily designed material prevented adequate sampling.

Taking all previous methods of smolt capture into consideration, an adequately-constructed weir was selected as the most suitable device for the 1965 smolt sampling program.

#### PURPOSE

Since 1956 returning adult sockeye salmon have been spawning in Frazer Lake. These adults were the first to return from the egg planting program of 1951 and were carried over the falls until 1962 when fish passage facilities were installed allowing returning sockeye to enter the lake. Program emphasis at that time was on stocking and counting adult spawners. Little was known about the effects which the stocking efforts had on productivity, since smolts were not counted as they migrated from the lake.

The primary purpose of the 1965 smolt study was to begin a sampling procedure that would provide information concerning: (1) the basic productivity of Frazer Lake, (2) adult and juvenile sockeye survival, and (3) the effects of sockeye introduction on a large lake system previously devoid of salmon.

#### CONSTRUCTION OF SMOLT WEIR

The site which was selected for the smolt weir was on Dog Salmon Creek 1/4 mile below the lake outlet and approximately 1/4 mile above Dog Salmon Falls. The width of the stream at the weir site was approximately 100 feet. The streambed at this location was composed of medium and small gravel and the average depth of the water was 2-1/2 feet during normal stream flow. The site was selected because of the level stream bottom and uniform depth of the water flow.

Lumber for the weir facilities was pre-cut at Kodiak and shipped to Moser Bay aboard the Alaska Department of Fish and Game vessel, M/V WIDGEON. At Moser Bay the lumber was loaded aboard a Department Grumman "Goose" and flown to Frazer Lake. Once at the lake the lumber was floated downstream to the weir site. The actual transportation of weir materials and its construction required three weeks of labor.

The weir was constructed by placing tripods and bipods in a V formation. The vertex of the V was placed at the point of swiftest current, and opened out upstream to form a funnel which would channel migrating smolts into the trap placed at the vertex. The trap consisted of a screened box, 8' x 4' x 4'. At the entrance of the trap a splash board was installed which could be raised or lowered depending on the water flow needed to efficiently operate the trap. Two bipods were placed at the back of the trap to secure the trap in a permanent position.

Once the tripods and bipods were in position they were anchored by means of cement-filled five-gallon cans suspended from the tripods and bipods. Stringers of 2" x 6" were placed on the upstream side and panels of 1/4 inch wire mesh screens were placed against them to complete the weir facing. This mesh size proved to be more than adequate in preventing smolt escapement. The final step in weir construction was to place sand bags at the base of the screens to prevent washouts.

#### SAMPLING PROCEDURE

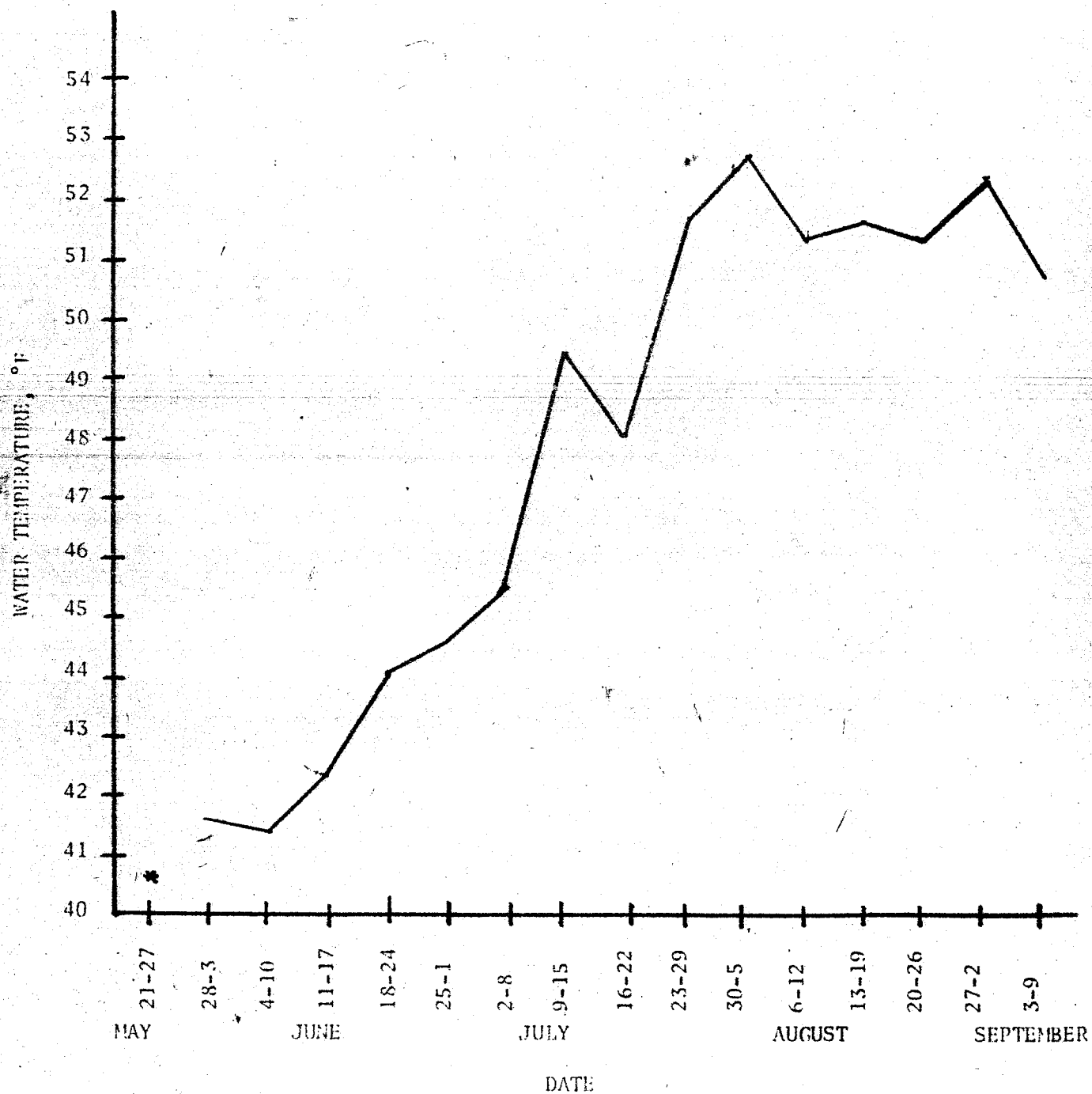
The weir was opened and sampling started on May 21, 1965 and continued until September 9, when extremely high water conditions necessitated closing the weir.

The smolt weir was checked twice daily, at 9:00 a.m. and at 4:00 p.m. Daily procedure included cleaning the weir screens and counting all species of fish found on the screens. The majority of fish found on the screens were cottids (*Cottus aleuticus*). In most instances the cottids were dead due to their inability to overcome the force of the water pressure exerted upon them. After counting the fish on the screens the water temperature was recorded (Figure 3).

The number of smolts in the trap were then estimated and if the estimated number was less than 100, all smolts were measured. If, however, the estimated number was more than 100, then at least 100 fish were picked at random throughout the sample. The unmeasured smolts were counted and placed back in the stream. The smolts to be measured were anesthetized in MS 222 (tricaine methanesulfonate) for a period of 1 to 5 minutes. When a smolt was



Figure 3. Average weekly water temperatures taken at the smolt weir daily about 9:00 A.M.



\* No temperatures recorded.

completely relaxed it was placed on a wet sheet of 10 millimeters to the centimeter graph paper and the fork length was marked on the graph paper by pricking the paper at the fork of the tail with a probe (Meehan, in press). After each smolt was measured it was placed in a holding box until fully recovered, usually from 30 to 60 minutes. The sampled smolts were then released as a group.

The sampling procedure consisted of four separate operations:

1. All migrating fish were counted every day. Any mortality was recorded separately.
2. A minimum of 100 smolts were measured daily.
3. Scales were taken weekly from five smolts in each 5-millimeter size group.
4. Each week 25 smolts were sampled for weight, fork length and scales. The smolts that were used for weight samples were left in MS 222 until they died. Then they were immediately transported in a moist transparent plastic bag to the cabin where their weight was recorded on a one kilogram pan balance. The weight was recorded to the nearest tenth of a gram. Before being weighed, each smolt was blotted on a paper towel. Scales were taken from the left side of the fish immediately above the lateral line between the dorsal and adipose fins. A scalpel was used to remove the scales. The scales were then placed on microscope slides and the date, fork length and weight were recorded on each slide.

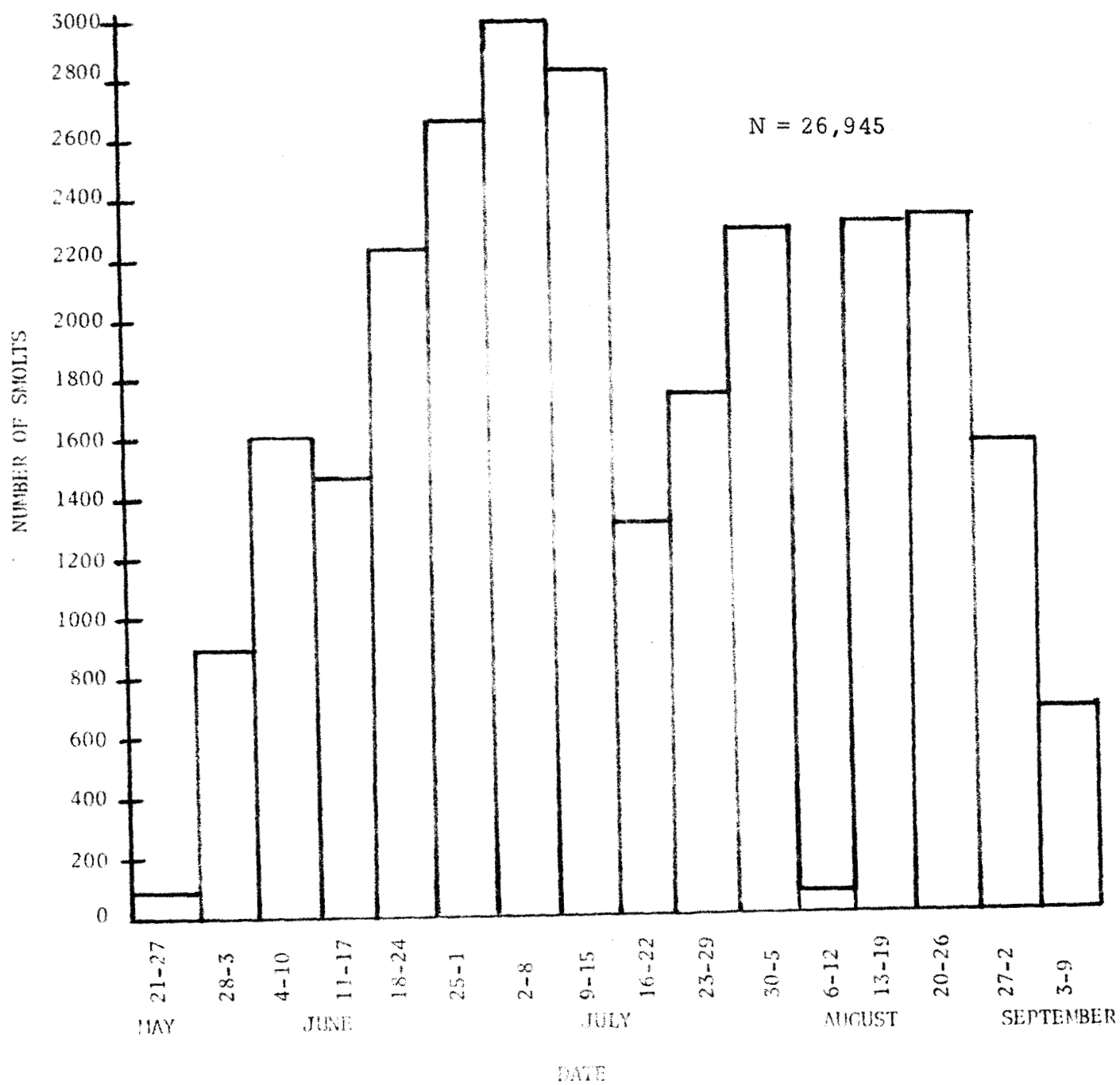
Sampling ended September 9, 1965, because of high water conditions caused by daily rain storms. A week prior to suspending operations approximately 60 to 70 smolts were counted daily.

#### TIMING OF SMOLT MIGRATION

Smolts began migrating seaward during the last week of May and reached a peak during the first week of July (Figure 4). Numbers dropped during the next two weeks, and then increased until approximately 2,200 smolts per week were counted for several weeks, with the exception of one week during which the weir was closed. During the two weeks prior to closing the weir for the season, the magnitude of the migration appeared to be on the decrease.

The 1965 smolt migration from Frazer Lake was extended over a much longer time period than migrations from most other sockeye systems. Generally, the majority of sockeye smolts have left a system by the end of June. The low density of rearing juveniles in Frazer Lake may be the major factor causing this unusual migration pattern.

Figure 4. Timing of smolt migration, Frazer Lake, 1965.



## LENGTH-FREQUENCY DISTRIBUTION OF SMOLTS

The lengths of migrating smolts varied from 80 millimeters to 214 millimeters (Figure 5). The dominant size group was 150-154 millimeters. The mean size group was 155-159 millimeters, which is quite large compared to similar data from other sockeye salmon systems in Alaska. The 155-159 millimeter smolts were largely age 2. fish.\* Some other systems in Alaska produce age 2. smolts as small as 80-100 millimeters, fork length. The large size of Frazer Lake smolts was probably due to the low density of juveniles in the lake and an abundant food supply.

The 1965 Frazer Lake smolt migration numbered 26,945 during the 3-1/2 months of sampling. Every day a minimum of 100 random fork length samples were taken. At the end of the season 10,067 fork lengths had been recorded. The number of smolts in each size group can be seen in Figure 5. The large sample number is the result of the staggered and prolonged migration. Migration patterns for Frazer Lake smolts had never been studied and, therefore, measurement procedure was based on previous procedures used at Little Kitoi and Ruth Lake weirs on Afognak Island (Meehan, in press).

Three separate samples were used to determine the age composition of the entire run: (1) daily random length samples, (2) weekly non-random length and age (from scale analysis) samples, and (3) total number of migrants.

Random fork lengths of at least 100 smolts were recorded every day. Since the samples of known age and length were not taken at random, but rather were taken to fill weekly size groups, they were projected to assign the age distribution to the random length samples. Using the known age and length data (Table 1) and projecting them over the random length frequencies (Table 2), age distribution for the random length sample was obtained. Once this had been done, the data was extrapolated to obtain the approximate age composition, of the entire run (Table 3). Using this method, 6.4 percent of the smolts were 1-check (age 1.), 72.4 percent were 2-check (age 2.), and 19.4 percent were 3-check fish (age 3.).

## AGE CLASS DISTRIBUTION OF SMOLTS AND TIMING BY AGE

Three age classes were represented during the 1965 smolt migration (Figure 6). At the beginning of the season (May 21) 3-check smolts comprised

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\* A number preceding the period represents the number of freshwater checks. A number after the period represents the number of saltwater checks. Thus, a 2.2 fish is in its 5th year having 2 winters in fresh and 2 winters in saltwater.

Figure 5. Length-frequency distribution of random sample of 10,067 smolts, Frazer Lake, 1965.

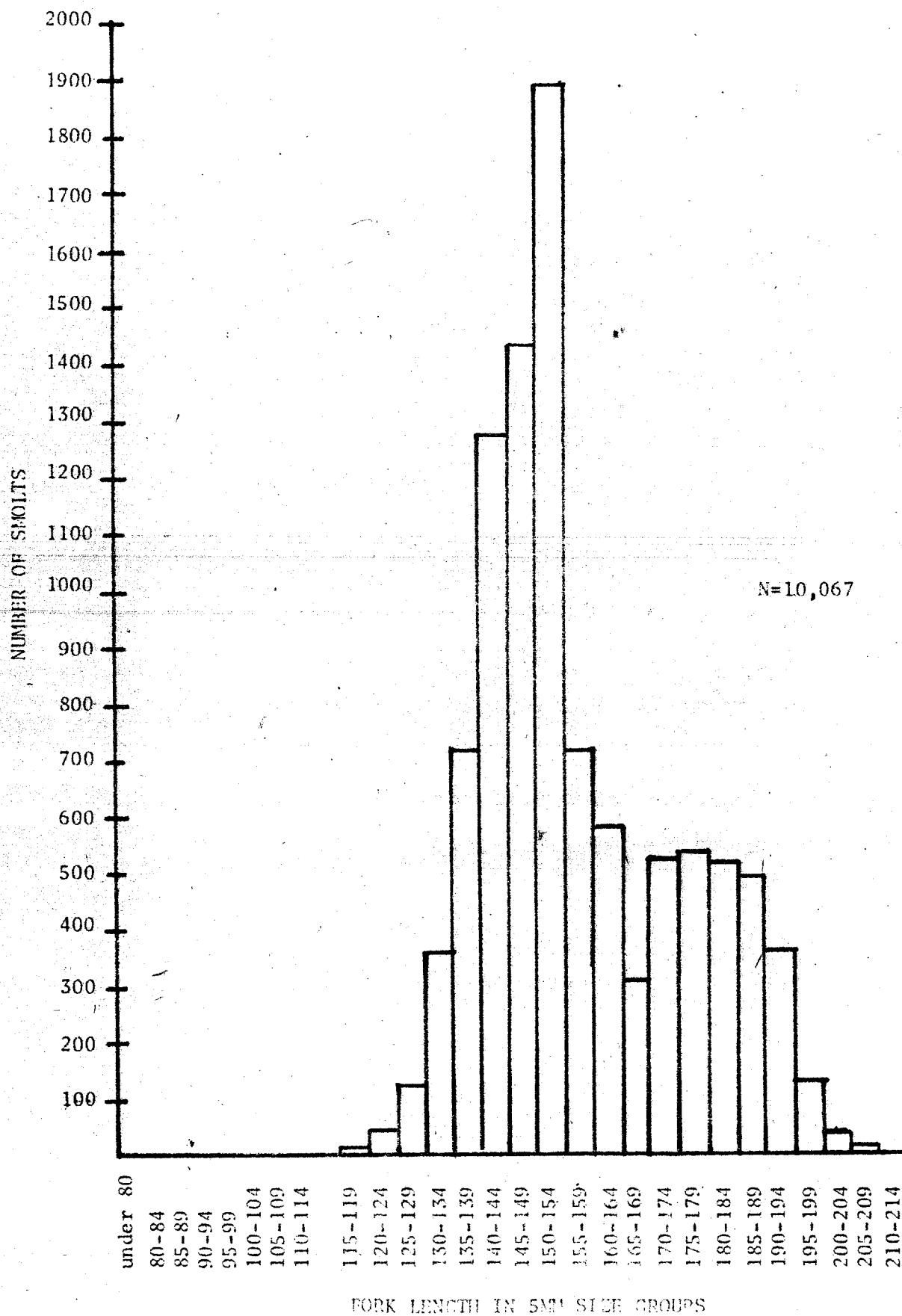


Table 1. Age composition of non-random length sample of smolts.

Size Group (Fork length in mm)	Sample Size	Number of Smolts of Age		
		1.	2.	3.
less than 80	1	1	0	0
80-84	0	0	0	0
85-89	1	1	0	0
90-94	4	4	0	0
95-99	2	2	0	0
100-104	2	2	0	0
105-109	1	1	0	0
110-114	3	3	0	0
115-119	9	8	1	0
120-124	26	22	4	0
125-129	40	22	18	0
130-134	42	15	27	0
135-139	46	11	35	0
140-144	58	14	44	0
145-149	62	4	58	0
150-154	57	0	57	0
155-159	61	0	61	0
160-164	60	0	58	2
165-169	58	0	55	3
170-174	48	0	39	9
175-179	43	0	31	12
180-184	30	0	4	26
185-189	29	0	3	26
190-194	27	0	2	25
195-199	26	0	0	26
200-204	17	0	0	17
205-209	10	0	0	10
greater than 210	1	0	0	1
<hr/>				
Total	764	110	497	157

Table 2. Age composition of random length-frequency sample, extrapolated from data presented in Table 1\*.

Size Group (Fork length in mm)	Sample Size	Number of Smolts of Age		
		1.	2.	3.
less than 80	1	1	0	0
80-84	0	0	0	0
85-89	2	2	0	0
90-94	4	4	0	0
95-99	2	2	0	0
100-104	2	2	0	0
105-109	1	1	0	0
110-114	3	3	0	0
115-119	9	9	0	0
120-124	40	40	0	0
125-129	122	61	61	0
130-134	356	118	238	0
135-139	711	142	569	0
140-144	1,276	255	1,021	0
145-149	1,433	0	1,433	0
150-154	1,892	0	1,892	0
155-159	717	0	717	0
160-164	579	0	579	0
165-169	303	0	303	0
170-174	524	0	524	0
175-179	534	0	134	400
180-184	520	0	0	520
185-189	492	0	0	492
190-194	362	0	0	362
195-199	130	0	0	130
200-204	36	0	0	36
205-209	13	0	0	13
210-214	3	0	0	3
Total	10,067	640	7,471	1,956

\* Key used to divide size groups into the appropriate age classes:

1 - check smolts		2- check smolts	
1.	80-124 mm	2.	50% 125-129 mm
	50% 125-129 mm		67% 130-134 mm
	33% 130-134 mm		80% 135-139 mm
	20% 135-139 mm		80% 140-144 mm
	20% 140-144 mm		145-174 mm
			75% 175-179 mm
3-check smolts			
3.	25% 175-179 mm		
	180-214 mm		

Table 3. Calculations used to determine approximate age composition of all sockeye smolt migrants, Frazer Lake, 1965.

1. No. of 1-check smolts in random sample (Table 2) - 640
2. No. of 2-check smolts in random sample (Table 2) - 7,471
3. No. of 3-check smolts in random sample (Table 2) - 1,956
4. Total random length frequency sample (Table 2) - 10,067
5. Total number of smolts counted through weir - 26,945

Total number (and percent) of 1-check smolts in migration

$$\frac{640}{10,067} = \frac{X}{26,945} = 1,713 \text{ (6.4 percent)}$$

Total number (and percent) of 2-check smolts in migration

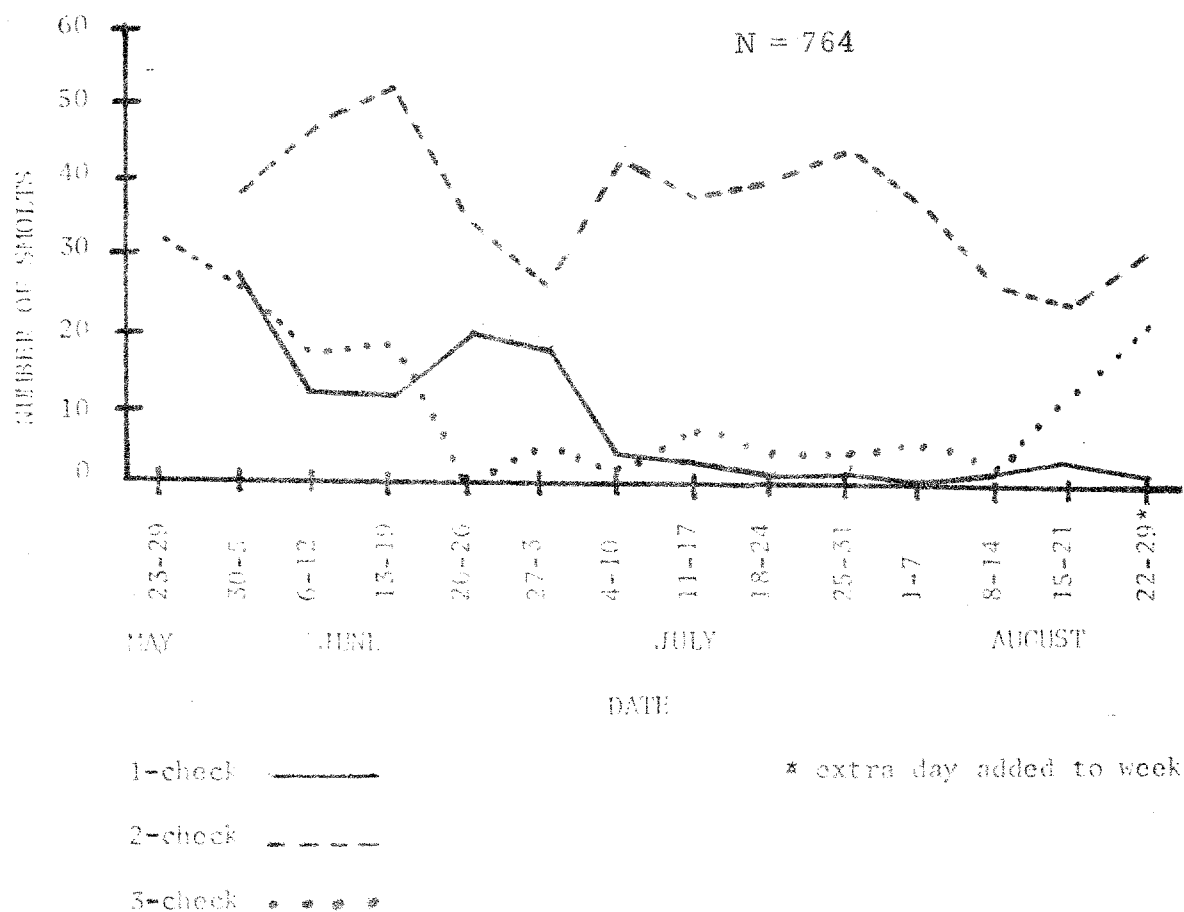
$$\frac{7,471}{10,067} = \frac{X}{26,945} = 19,996 \text{ (74.2 percent)}$$

Total number (and percent) of 3-check smolts in migration

$$\frac{1,956}{10,067} = \frac{X}{26,945} = 5,235 \text{ (19.4 percent)}$$



Figure 6. Timing of migration by week as indicated by the number of smolts of each age class in the samples, Frazer Lake, 1965.



the majority of migrants. One week later 2-check smolts became the dominant age class, and remained as such until the last week of August. One-check smolts and 3-check smolts varied in dominance throughout the season; however, more 3-checks left the lake than did 1-check smolts.

The extra year of residence in fresh water of the majority of smolts was probably the result of limited numbers of smolts in the lake and abundant food supply. If this were the case it would also explain the relatively large number of 3-check smolts in the migration. Plankton sampling has shown that the lake is very productive.

The three age classes which made up the 1965 smolt migration are the progeny of the 1961, 1962, and 1963 adult spawning runs respectively. In 1961 the adult escapement into Frazer Lake was 273, and 600 adults were transplanted from nearby Red Lake. In 1962, 1,800 adults were transplanted from Red Lake and the escapement was 1,290 fish. In 1963, 9,500 adults were transplanted from Red Lake and the escapement was 2,357 sockeye.

Further studies on age class migration patterns are needed to reach an understanding of sockeye salmon production in the lake.

#### CONDITION FACTOR

Each week 25 smolts were selected from the dominant weekly size group. The dominant size groups each week ran from the 134-139 millimeter group to the 164-169 millimeter group. Some mean weights are as follows:

Fork length (millimeters)	Weight (grams)
135	21.4
139	25.3
140	25.1
144	23.8
145	25.5
149	27.8
150	25.9
154	31.9
155	32.8
159	34.9
169	41.7

Using the formula  $K = \frac{W \times 10^N}{L^3}$  the condition factor for each smolt was calculated, and the mean condition factor was determined for each age class. Two-check smolts were the only ones which were sufficiently represented throughout the migration to provide adequate weekly comparisons (Table 4).

Table 4. Average weekly condition factor (K) for smolts of various ages, Frazer Lake, 1965.

Date	Average Condition Factor (K) and Sample Size (N) for Smolts of Age					
	1.		2.		3.	
	K	N	K	N	K	N
3-9	.907	46	.893	33	.903	20
JUNE 10-16	.872	20	.901	5	----	0
24-30	.876	16	.890	9	----	0
1-7	.804	5	.817	20	----	0
JULY 8-14	----	0	.867	25	----	0
15-21	----	0	.883	25	----	0
22-28	----	0	.890	50	----	0
AUG. 29-4	----	0	.894	25	----	0
26-29	----	0	.870	13	----	0
For Entire Season	.864	87	.878	205	.903	20

A general decrease in condition factor was observed as the season progressed, although fluctuations occurred from week to week.

The increase in mean condition factor with age of smolts may be the result of inadequate samples of 1-check and 3-check smolts. Further data is necessary before any generalizations can be made in this respect.

#### PREDATION ON SMOLTS

The procedure of releasing smolts in the morning after they had recovered from anesthetization had to be discontinued early in the season because of their susceptibility to predation by gulls. The non-anesthetized smolts seemed to escape predation. To prevent further predation, smolts were released in the late afternoon when gulls were absent from the weir area.

Evidence of predation by otters on smolts in the holding box was found on several occasions, although they accounted for only a limited smolt mortality.

On four separate occasions a female Harlequin duck and several ducklings were found in the smolt box; however, there was no indication that they were fishing. The ducklings were believed to have been swept into the trap, and the female duck had entered to free them and had become trapped herself.

Smolt mortality was caused by high water conditions and increased velocity which forced some smolts against the screens near the trap, where they eventually died from suffocation. To lessen mortality of this type the three screen panels on each side of the box were allowed to plug up with debris, primarily algae.

In order for the trap to operate efficiently, a water level of at least 2 feet was required. If the water level exceeded 3 feet, the increased water pressure caused trapped smolts to constantly fight the water flow, causing exhaustion and eventually death. Maintenance of optimum water level was achieved by regulating the screen-cleaning process. If the water level dropped, screens were allowed to plug up with algae, and if the water level raised, the screens were cleaned at necessary intervals.

Smolt mortality was nearly 10 percent of the total migration (Table 5). The mortality caused by predation was not known and the figures in Table 5 represent only mortality caused by the weir. By installing baffles in the trap to break up water flow and create still water areas, and by controlling stream level by means of the weir screens, smolt mortality can probably be reduced considerably in future years.

Table 5. Total number and mortality of various species of fish trapped by downstream smolt weir, Frazer Lake, 1965.

Species	Total number trapped	Mortality	
		Number	Percent
Sockeye salmon ( <u>O. nerka</u> )	26,945	2,610	9.7
Coho salmon ( <u>O. kisutch</u> )	8	0	0.0
Dolly Varden char ( <u>S. malma</u> )	519	30	5.8
Rainbow trout ( <u>Salmo gairdneri</u> )	12	0	0.0
Threespine stickleback ( <u>Gasterosteus aculeatus</u> )	451	432	95.8
Cottid ( <u>C. aleuticus</u> )	15,583	12,173	78.8

## SUMMARY

1. A sockeye salmon smolt study was initiated at Frazer Lake in the spring of 1965. The program will continue for at least 5 years.
2. Stream water temperatures taken during the 14-week sampling period in 1965 indicated a minimum water temperature of 41.5° F. and a maximum water temperature of 53.0° F.
3. The sockeye smolt migration in 1965 reached a peak in early July, but extended at an unusually high level throughout the 14-week field season.
4. The average fork length of sockeye smolts was 155-159 millimeters.
5. The migration contained three age classes with 2-check smolts comprising 74.2 percent of the run.
6. A total migration of 26,945 smolts were enumerated.
7. The primary source of smolt mortality was due to the physical characteristics of the weir and box during periods of extremely swift and high stream flow.

## REFERENCES

Meehan, William R. In press.

Growth and survival of sockeye salmon introduced into Ruth Lake after removal of resident fish populations. USFWS, Special Scientific Report.

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